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GENERAL DYNAMICS | CONVAIR

Report No. 8926-087

Materials - Finishes and Coatings - Anti-Galling -
For Titanium Masterworks

Seizure Characteristics

R. R. Reschan, E. E. Keller, W. M. Sutherland

22 December 1958

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MODEL
DATE

PAGE
REPORT NO.

Report No. 8926-087

**Materials - Finishes and Coatings - Anti-Galling -
For Titanium Fasteners**

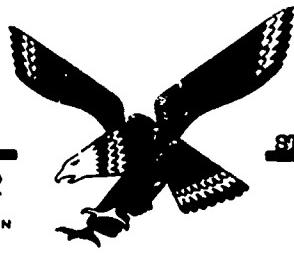
Seizure Characteristics

Abstract

The number of turns required to cause 1/2 inch hexagonal Ti 6Al-4V nuts to seize on 1/2 x 3 inch, MS 20008-43 type, Ti 4Al-4Mn bolts under a tension (axial) load applied to a nut and bolt assembly was used as a comparison criterion. Uncoated, fluoride-phosphate (Titanium Metallurgical Laboratory Memo, date 30 October 1956), Ti-Oxide anodic treated (San Diego Plating Co., San Diego, California) Hardax anodic treated (Anachrome Corp., South Gate, California), Electrofilm 66C (baked epoxy resin - molybdenum disulfide finish, San Diego Plating Co.), silver- and nickel-plated (Steel Improvement and Forge Co., Cleveland, Ohio), and heat treated (1000°F, 4 hours in air, air cool) nuts were treated. The test results showed that nuts which were silver-plated or electrofilm coated were about equal to each other and superior to the other surface treatments in resisting galling. The anodic treatments used had the greatest tendency for seizure, in some cases greater than that of the bare nuts used as a standard of comparison.

Reference: Reschen, R. R., Keller, E. E., Sutherland, W. H., "Titanium Anti-Galling Treatment for Threaded Assembly," General Dynamics/Convair Report MP 58-287, San Diego, California, 22 December 1958.
(Reference attached.)

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A DIVISION OF GENERAL DYNAMICS CORPORATION
SAN DIEGO

STRUCTURES & MATERIALS LABORATORIES

REPORT MP-58-287

DATE 22 December 1958

MODEL PEA 7028

TITLE

REPORT NO. MP-58-287

TITANIUM ANTI-GALLING TREATMENT FOR THREADED ASSEMBLY

RRA 7028

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NO. OF PAGES 9

NO. OF DIAGRAMS 7

REVISIÖNS

ANALYSIS

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CONVAIR

SAN DIEGO

PAGE 1

REPORT NO. MP-58-287

MODEL RMA 7028

DATE 12-22-58

Report No. MP-58-287
Titanium Anti-Galling Treatment
for Threaded Assembly - RMA 7028

OBJECT:

To determine the torque-tension relationship and galling characteristics of titanium nuts, bare and as surface treated by seven different processes, when installed on bare titanium bolts.

CONCLUSION:

Tests show that silver plating on titanium and electrofilm 66C per Convair Specification O-05000 are two surface treatments which will greatly reduce any galling or seizure of titanium nuts to bare titanium bolts. Nickel plating on titanium, heat treating of titanium at 1000°F for four hours, and the Hardas Process anodic treatment by Anachrome Corp. are three surface treatments that are no better, and in some instances less resistant to galling than bare to bare titanium nut and bolt.

The fluoride-phosphate treatment for titanium and the Ti-oxide anodic treatment by San Diego Plating Co. are about equal and slightly more resistant to galling than the bare nut used as a standard.

TEST SPECIMEN:

1. Bolts: - Type 64, 1/2" x 3" titanium bolts with the configuration of the type MS 20008-43 for steel bolts.

2. Wafers: - Type 64, 1/8" x 7/8" hexagonal titanium wafers processed along with the nuts. Wafers were used as a standard to measure any dimensional increase or decrease of titanium nuts due to process treatment.

3. Nuts: - Type 64, 1/2" titanium hexagonal nuts were processed by each of the following methods:

- a) Eight bare titanium nuts - no processing, used as a standard.
- b) Eight nuts and two wafers processed by the Fluoride-Phosphate chemical conversion method as outlined in the Battelle memo of 10-30-56. Processing done in the Materials and Processes Laboratory.
- c) Eight nuts and two wafers given the Ti-Oxide anodic treatment by the San Diego Plating Co.
- d) Eight nuts and two wafers processed by the Anachrome Corp., South Gate, Calif. and given the Hardas Process anodic treatment.

4. Bolts - 4 Al-4 Mn titanium alloy

5. Nuts - 6 Al-4 V

HT SPECIMEN: (Continued)

- e) Eight nuts and two washers Electrofilmed 66C per Convair Specification O-05000 by the San Diego Plating Co.
- f) Two silver-plated nuts processed by the Steel Improvement and Forge Co. of Cleveland, Ohio. Silver plate thickness .0005 in.
- g) Two nickel-plated nuts processed by the Steel Improvement and Forge Co. of Cleveland, Ohio. Nickel plate thickness .0005 in.
- h) Three titanium nuts and one washer heat treated at 1000°F for four hours and removed from furnace and air cooled. Heat treatment done by Materials and Processes Metallurgical Heat Treat Lab.

TEST PROCEDURE:

A special jig was constructed (Fig. 1) which would permit the mounting of the bolt and nut on the Tinius Olsen Universal Testing Machine, thereby providing a means of applying a tension load of 10,000 lbs. for the start of each test. This load was used as the starting point before doing any torquing of the nut with a hand torque wrench.

The torque wrench was applied to the nut and rotated to the right through a 90° arc. At this same time the greatest torque in ft-lbs shown on the wrench dial was recorded. The load shown on the Tinius testing machine was also recorded. At this point the wrench was backed off 90° to the starting position. Break torque was recorded and also tension shown on the test machine was recorded when the wrench reached the starting position.

The starting load of 10,000 lbs was then again applied to the jig before torquing the nut the second, third, fourth, etc. times. This procedure was repeated until in some tests seizure or extreme galling of the nut and bolt threads was evident.

A new cadmium plated steel washer was inserted between the treated nut and steel plate each time a treated nut was tested. (Fig. 1)

Due to the shortage of titanium bolts, two nuts were tested on each bolt. One at the shank end of the bolt and then one at the very end of the bolt.

RESULTS:

Test results are listed in Table 8 and shown graphically in Figure 2.

ANALYSIS

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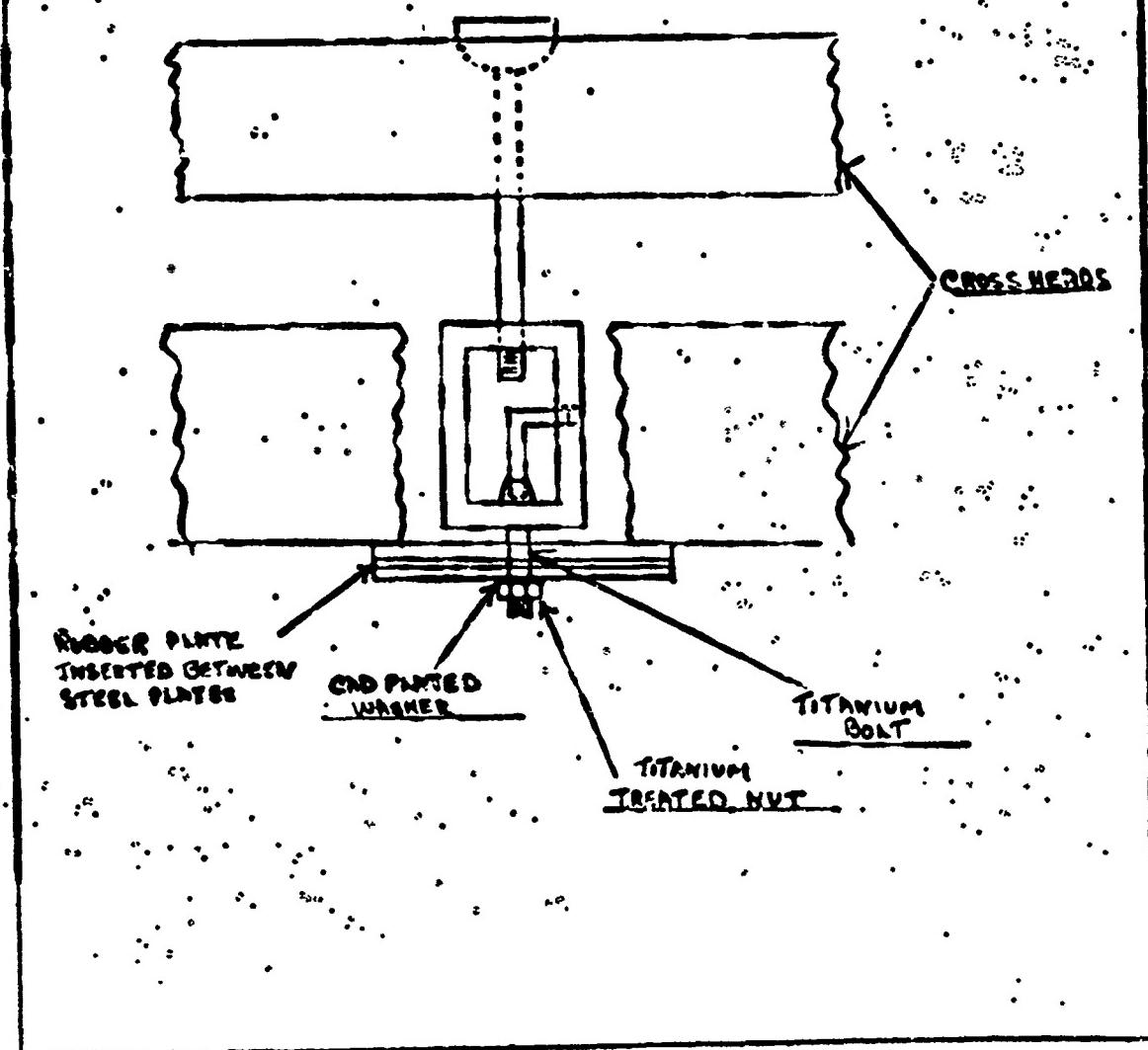
REPORT NO. MP-58-287

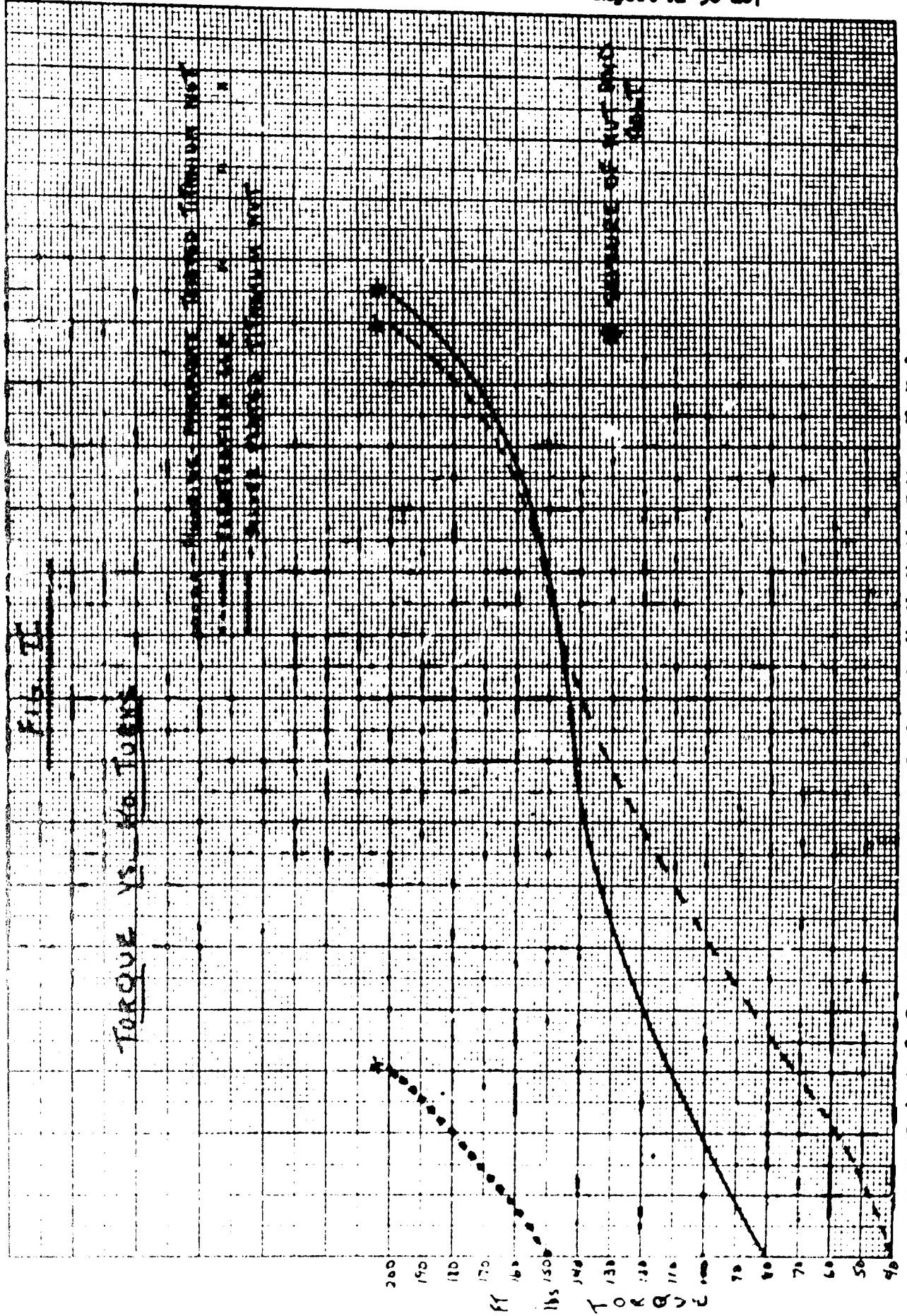
MODEL REA 7028

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FIG. I

TITANIUM NUT AND BOLT SHOWN ASSEMBLED
IN JIG AND MOUNTED ON THE TINIUS OLSEN
UNIVERSAL TESTING MACHINE





ANALYSIS
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MODEL REA 7028
DATE 12-22-58

TABLE I

Test No.	Specimen	No. of Rotations	Ft.lbs.Torque Required	Ft.lbs Break-away Torque	Tension Load Recorded	Tension Load Release
1	Bare Nut	0.5	200	Seizure - Bolt Fractured when backed off		
2	Electrofilm 66C	1	50	50	11,260	- -
		2	45	50	11,200	- -
		3	45	50	11,250	- -
		4	50	55	11,500	- -
		5	55	45	11,880	- -
		6	65	50	11,600	- -
		7	75	55	11,560	- -
				Test stopped at this point.		
3	Electrofilm 66C	1	45	25	11,595	8,800
		2	45	30	11,300	9,500
		3	45	30	11,380	9,500
		4	50	35	11,400	9,570
		5	55	50	11,440	9,600
		6	60	45	11,500	9,370
		7	70	50	11,920	10,340
				Test stopped at this point.		
4	Electrofilm 66C	1	50	50	11,650	9,900
		2	50	50	11,800	9,400
		3	50	55	11,450	9,100
		4	60	60	11,950	9,700
		5	60	65	12,000	9,550
		6	90	55	12,250	9,800
		7	65	60	12,400	9,800
		8	85	90	12,100	9,950
		9	95	85	12,300	9,850
		10	90	95	11,500	9,950
		11	100	90	11,800	9,800
		12	100	95	11,850	9,900
		13	110	100	11,900	9,950
		14	115	100	11,900	9,950
		15	120	100	11,800	9,800
		16	120	100	11,800	9,900
		17	125	110	11,800	9,800
		18	125	110	11,700	9,850
		19	130		Test stopped - seizure of nut and bolt at this point.	

ANALYSIS

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TABLE I (CONTINUED)

Test No.	Specimen	No. of Rotations	Ft.lbs.Torque Required	Ft.lbs. Break-away Torque	Tension Load Recorded	Tension Load Release	
5	Electrofilm						
	36C	1	40	20	11,600	9,400	
		2	40	30	12,000	9,700	
		3	45	25	12,100	9,800	
		4	50	30	12,300	9,900	
		5	60	40	12,400	10,000	
		6	65	40	12,200	9,900	
		7	65	50	12,300	9,900	
		8	75	55	12,300	9,900	
		9	85	60	12,200	10,000	
		10	90	60	12,100	9,900	
		11	90	70	12,100	9,900	
		12	100	90	12,000	9,900	
		13	100	100	12,000	9,900	
		14	110	100	12,000	9,900	
		15	120	100	12,000	9,900	
		16	130	110	"	"	
		17	130	120	"	10,100	
		18	140	120	11,800	9,900	
		19	140	130	"	"	
		20	140	130	"	"	
		21	150	130	11,700	"	
		22	150	130	"	"	
		23	160	130	"	"	
		24	160	140	"	"	
		25	160	130	"	"	
		26	160	140	"	9,800	
		27	170	140	"	9,900	
		28	170	150	"	"	
		29	180	150	11,600	"	
		30	180	150	11,600	10,500	
		31	200	Test stopped - seizure of nut and bolt at this point.			
6	Nickel Plated	1	130	110	10,850	--	
				Test stopped - seizure of nut and bolt at this point.			
7	Nickel Plated	1	200	150	10,600	9,600	
		2	-	Stopped - seizure of nut and bolt.			
8	Heat Treated. 1000°F	1	200	Stopped - seizure of nut and bolt.			

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TABLE I (CONTINUED)

Test No.	Specimen	No. of Rotations	Pt.lbs.Torque Required	Ft. lbs.Break-away Torque	Tension Load Recorded	Tension Load Release
9	Silver Plated	1	80	20	11,000	9,150
		2	90	30	11,250	9,450
		3	90	20	11,400	9,775
		4	90	90	11,350	9,850
		5	100	80	11,300	9,850
		6	110	120	11,350	10,000
		7	110	90	11,200	9,950
		8	120	100	11,250	9,990
		9	120	100	11,250	10,000
		10	130	100	11,150	9,950
		11	130	110	11,150	9,950
		12	130	120	11,200	10,000
		13	130	120	10,800	9,605
		14	130	120	10,850	9,700
		15	140	120	11,100	9,950
		16	140	120	11,150	9,950
		17	140	120	11,250	9,950
		18	140	130	11,250	9,850
		19	145	130	11,150	9,950
		20	150	140	11,150	9,900
		21	150	130	11,200	10,000
		22	150	130	11,050	9,950
		23	150	140	11,100	10,000
		24	155	140	11,100	10,000
		25	160	140	11,050	10,000
		26	160	140	12,300	9,800
		27	160	140	"	9,700
		28	170	150	"	9,800
		29	180	150	"	9,700
		30	180	150	12,300	9,700
		31	180	160	12,300	10,000
		32	200	Seizure of nut to bolt.		
10	Silver Plated	1	90	50	11,170	9,660
		2	70	40	11,280	10,000
		3	70	50	11,360	9,640
		4	70	50	11,140	9,580
		5	70	50	11,140	9,580
		6	80	60	11,340	9,860
		7	80	60	11,580	10,080
		8	85	60	11,200	9,860
		9	90	65	11,220	9,700
		10	90	65	10,840	9,180
		11	90	70	11,150	9,540
		12	95	75	11,340	9,800

ANALYSIS

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 REPORT NO. IF-58-287
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 DATE 12-23-58

TABLE I (CONTINUED)

Test No.	Specimen	No. of Rotations	Ft.lbs.Torque Required	Ft.lbs.Breakaway Torque	Tension Load Recorded	Tension Load Release
10 Silver Plated (Continued)						
13		100		75	11,350	- "
14		100		75	11,380	8,250
15		100		80	11,420	9,600
11 Bare Nut						
1		150		130	10,500	8,800
2		150		130	"	8,600
3		150		140	11,000	9,500
4		160		140	11,300	9,700
5		160		140	11,400	9,700
6		200		200	Seizure of nut and bolt.	
12 Hardas Anodic Treatment						
1		200		170	11,300	9,100
2		190		170	11,300	8,500
3		190		170	11,800	9,300
4		200		180	12,000	9,500
5		200		170	12,000	9,500
6		200		180	12,000	9,500
Stopped Test - galling of nut and bolt from the start.						
13 Fluoride-Phosphate Treated						
1		150		140	11,000	9,100
2		160		150	11,300	9,500
3		170		150	11,500	9,600
4		180		160	"	9,700
5		180		170	"	9,600
6		180		170	"	9,500
7		180		150	"	9,600
8		180		170	"	9,700
9		200		Seizure of nut and bolt.		
14 Fluoride-Phosphate Treated						
1		150		130	10,300	9,100
2		160		150	10,400	9,150
3		170		150	10,800	9,450
4		170		150	10,950	9,600
5		170		160	11,000	9,900
6		180		200	10,900	Seizure of nut and bolt.

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MODEL REA 7028
DATE 12-22-58

TABLE I (CONTINUED)

Test No.	Specimen	No. of Rotations	Ft.lbs.Torque Required	Ft.lbs.Break-away Torque	Tension Load Recorded	Tension Load Release
15	Ti-Oxide Treated	1	110	70	11,150	9,150
		2	120	100	11,250	9,500
		3	130	110	11,250	9,600
		4	140	120	11,150	9,650
		5	140	120	11,250	9,650
		6	150	130	11,250	9,950
		7	150	130	11,150	10,000
		8	150	160	11,050	Seizure of nut and bolt.